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AN OPINION ON THE INITIAL SUCCESS OF THE 3,000-TON-HAUL TEST BY TIENTSIN RAILWAY BUREAU, FENG-T'AI -- TIENTSIN, JUNE 1950

Prepared by the Head Office of the Rolling Stock Department,
Ministry of Railways

I. REASONS FOR TEST

Reports from the Northeast continue to come in concerning new records in load hauling. After the report was circulated that a Mikado No 1 locomotive in the Northeast had hauled 3,062 metric tons, it aroused a great variety of opinions on the part of the railway men throughout the country. The report raised questions of locomotive maintenance, coupler strain, control of long trains, boiler scale, collection of cargo, length of tracks in marshaling yards, and other matters. Some thought this was only a freak performance and not feasible in regular practice. Others believed that a Mikado No 1 locomotive could haul 3,500 metric tons on the level with proper technical handling. Some believed that hauling 3,000 metric tons was possible for some locomotives but not for all.

To investigate the questions involved, the Tientsin Railway Bureau conducted a test on 24 June 1950 on the Peiping--Shan-hai-kuan line between Feng-t'ai and Tientsin.

II. NATURE AND RESULTS OF TEST

A. The Locomotive

A Mikado No 1 locomotive, No 1751, was used for the test. This locomotive had run 20,283.4 kilometers since having undergone in the preceding April a medium inspection and repair job, and the total kilometrage to its credit

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was 55,439.7 kilometers of safe running. The locomotive had run 911.8 kilometers since the previous boiler cleaning and inspection job. Just before the hauling test began, there was a 100-second leak in the steam chamber, an 85-second leak in the right cylinder and a 54-second leak in the left cylinder. There was 9.8 millimeters of /lost?/ motion in the left cylinder and 12.8 millimeters in the right cylinder. The locomotive could be called an engine in moderately good condition.

B. The Train

The train consisted of 71 loaded cars having a total weight of 2,983.9 metric tons, and it was 715 meters long.

C. Conditions of the Run

1. Starting. Before starting, the steam pressure was 13.4 kilograms per square centimeter; the water level at 60 percent full; the fire bed was 300 millimeters thick. Everything was in fine shape; the proper amount of sand was on the rails. Most of the car couplers were in the compressed position so that the whole length of the train would not begin to move simultaneously. Thus there was no slippage of drive wheels on starting; starting was very easy.

2. Running. The throttle was 80 percent open or better; the reverse mechanism was set at 30 percent position. The steam pressure was kept constant. The water level varied from 60 percent to 20 percent. The highest running speed was 52 kilometers per hour.

3. Stopping. The brakes were applied by reducing the air pressure one kilogram. It took 53 seconds to release the brakes. The time required to bring the train to a stop was 2 minutes (including coasting time). Because the time required to restore the air pressure was comparatively long, some advantage was lost.

4. Line conditions. Starting from Feng-t'ai on a 0.2 percent upgrade, the slope increased to 1.5 percent (where the train speed was 22 kilometers per hour). Subsequently, much of the way was downgrade from 0.9 percent to 1.5 percent.

5. Results. The total elapsed travel time was 3 hours and 25 minutes. The /average/ travel speed was 35.5 kilometers per hour; running time, 3 hours 3 minutes. The /average/ running speed was 39.6 kilometers. The coal consumed was 5.4 metric tons; this is at the rate of 150.2 kilograms per 10,000 metric ton-kilometers. (In the Feng-t'ai Division, the average coal consumption for May was 203.3 kilograms per 10,000 metric ton-kilometers.)

6. This test showed that a Mikado No 1 locomotive in average condition could unquestionably pull 3,000 metric tons on the level, or on grades up to 3 percent, in the summer time. However, the running speed could not be maintained during this test because much of the road from Feng-t'ai to Tientsin is slightly downgrade, which is a favoring factor.

III. PROBLEMS INVOLVED

A. Locomotive Maintenance

In the design of locomotives, each part is given a definite safety factor; therefore, there should be no good reason for not using the engine up to its full capacity. From the standpoint of steam pressure, water level, [redacted] STAT

and firing conditions in this test, the locomotive revealed surplus power and sustained no apparent damage. As a result of the greater friction between the brake shoes and the tires, and between the flanges and the rails, the wear on the wheels was certainly greater than usual. Nevertheless, on the whole, the hauling of heavier loads is economical.

B. Coupler Problems

The maximum tractive power of the Mikado No 1 locomotive is 20,700 - (162 x 8) = 19,400 kilograms (taking the starting resistance of the locomotive to be overcome at 8 kilograms per ton). The couplers of the first car behind the locomotive tender must be capable of sustaining a pull of 19.4 metric tons. Most cars in China are equipped with "Ch'ai-t'ien" couplers. There are also E, D, A, and J types. The Ch'ai-t'ien, D, and E types are standard. The D and E types are bigger than the Ch'ai-t'ien couplers; the A and J types are smaller. However, only a few of the latter types are in use and only on small cars.

In tests, the Ch'ai-t'ien couplers first showed signs of deformity under a strain of 132 metric tons. Allowing a safety factor of 3, the safe load that they could handle is 44 metric tons, which is much greater than 19.4 metric tons. Hence there is no question about cars equipped with standard couplers being able safely to sustain the pull of a 3,000-metric-ton train. Under tests, the A-type couplers first showed signs of deformity of the lips under a strain of 40 metric tons. Allowing a safety factor of 3, the safe load for this type of coupler is 13.4 metric tons, which is less than 19.4 metric tons, and hence this type of coupler is unsuitable for use in a 3,000 metric ton train.

The standard spring follower plates (which are separated from the center beams of the cars by 305 millimeters) are able to stand pressures up to 68 metric tons. With a safety factor of 3, its safe load is 23 metric tons, which makes it suitable for use in a 3,000-metric-ton train. The cheek plates stood up in tests under a pressure of 57 metric tons, which with a factor of safety of 3, makes them safe for a load of 19 metric tons. This is not far from 19.4 metric tons, and hence they may be considered suitable for use on trains of 3,000 metric tons. Therefore, under ordinary circumstances, the standard couplers in use are suitable, but A- or J-type couplers are not suitable for use in 3,000-metric-ton trains.

C. Braking Problems

In the current test, the braking time was 2 minutes, and the braking distance 600 meters, with an air pressure reduction of one kilogram. It required 53 seconds to pump off the air pressure reduction. Some jolting and jerking of the cars was to be expected. If the engineer had not been skillful in controlling the air, severe strains on some of the couplers might have resulted in damaging them or the cars. Many of the center beams on the cars in use at present are telephone poles and many of them are sagging; thus they are particularly vulnerable when braking thrusts are too great. Some couplers have been changed from high to low position and riveted in place. Such are easily damaged by heavy shocks.

D. Boiler Scale

The distance from Feng-t'ai to Tientsin is 120.3 kilometers. According to the Feng-t'ai Division statistics for May 1950, Mikado No 1 locomotives hauled trains averaging 1,389 metric tons on the Feng-t'ai--Tientsin run, and their average rate of coal consumption was 203.3 kilograms per 10,000 metric ton-kilometers. For each train trip they were averaging 3.4 metric tons of coal $\left(\frac{1389 \times 120.3 \times 203.3}{10,000}\right)$. Assuming that each metric ton of coal consumed converted 6 metric tons of water into steam, each trip would require 20.4 metric tons of water (3.4 x 6). On the test run of 24 June 1950, the water consumption was 31.4 [sic] metric tons (5.4 x 6 = 32.4).

The total hardness of the water used on this run is rated as 18; of this 6 is permanent hardness and 12 is temporary hardness. Each degree of permanent hardness will produce 24.3 grams of scale ($CaCO_3$) per metric ton of water evaporated. Each degree of temporary hardness will produce 17.9 grams of scale ($CaCO_3$) per metric ton of water. Hence each metric ton of water will produce 360.6 grams of scale (6 x 24.3 + 12 x 17.9). Since the specific gravity of the scale is 2.6, this is equivalent to 138.7 cubic centimeters, or $\frac{138.7}{1,000,000}$ cubic meters. This type locomotive has a heating surface of 209 square meters. Hence each metric ton of water used will produce a layer of scale 0.000622 millimeters thick.

On the average Feng-t'ai--Tientsin run, one metric ton of water is required for each 5.9 kilometers $\left(\frac{120.3}{20.4}\right)$. In this particular test with a 3,000-metric-ton train, one metric ton of water was required for each 3.7 kilometers $\left(\frac{120.3}{32.4}\right)$. According to regulations, a washing inspection must take place after every 2,000 kilometers of operation. It is then computed that in each period between washings, the average accumulation of scale is 0.21 millimeters thick, $\left(\frac{2,000}{5.9} \times 0.000622\right)$. At the rate of scale accumulation in this test, in a regular inspection period, the average thickness of the scale would be 0.337 millimeters $\left(\frac{2,000}{3.7} \times 0.000622\right)$. This figure is well below 0.5 millimeters, which is the maximum figure per washing period permitted by the regulations. Thus it is considered that the problem of scale accumulation with 3,000-metric-ton trains is not a serious one.

IV. CONCLUSIONS

A. Feasibility

The hauling of 3,000-metric-ton trains between Feng-t'ai and Tientsin is feasible and advantageous. However, if this is to be made a regular operation, the following requirements should not be overlooked.

1. The trains should be handled only by technically trained and experienced train crews.

2. Only cars with standard couplers should be used.

3. Only cars whose center beams meet standard specifications should be used.

4. Class B and Class C inspections and repair jobs should be carried out more strictly.

5. Cars whose couplers have been changed, should not be incorporated into such trains.

6. Tests should be made with trains running from Tientsin to Feng-t'ai, and personnel on inspection duty should take part in the tests.

7. Savings of at least 460 metric tons of coal per month could be realized, and one less locomotive per day could be used. This is computed on the basis of 180 trains in each direction each month between Feng-t'ai and Tientsin.

B. Possibilities

1. Generally speaking, after successful trial runs had been made, 3,000-metric-ton trains could be operated profitably on lines, or sections of lines, where the maximum grades do not exceed 3 percent.

2. There are 1,307.5 kilometers of railways in north and south China which meet the conditions for the operation of 3,000-metric-ton trains. This figure is 7.1 percent of the full length of the lines concerned. The lines or sections of lines where heavy train operation is practicable included the following:

Sections	Railway Line
Feng-t'ai--Ku-yeh	Peiping--Shan-hai-kuan
Te-chou--Tsinan	Tientsin--P'u-k'ou
Ta-t'ung--P'ing-ti-ch'uan (up)	Ta-t'ung-P'u-chou
Kuei-sui--Pao-t'ou (down)	Peiping--Suiyuan
Ch'ang-chou--Shanghai (up)	Shanghai--Nanking
Hsin-hsiang--Chen-chou (down)	Peiping--Hankow

If 3,000-metric-ton trains were hauled on all of the above sections, instead of the present loads, 90 fewer locomotives would be needed.

C. Losses Due to Underloading of Trains

The following data indicate that savings could be affected if locomotives were operated at their full capacity. The data is based on reports for April 1950 submitted by all the railway bureaus in north and south China.

Average loaded train load prescribed by the Ministry: 1,450 metric tons

Actual average loaded train load: 721 metric tons

Proportion of total train tonnage made up of empty cars: approximately one third

Average tonnage of empty trains: one third the prescribed tonnage, or 483 metric tons

Average prescribed train tonnage for all trains (loaded and empty): (1,450 - (1/3 x 2/3 x 1,450) = 1,128 metric tons

Degree of underloading of trains: $\left(1 - \frac{721}{1,128}\right) \times 100 = 36$ percent.

Total kilometrage: 2,203,558 kilometers

Actual number of pairs of trains: 7,712

Actual number of metric tons hauled: 7,712 x 2 x 721 = 11,120,704 metric tons [not necessarily metric tons originated]

Actual average daily kilometrage per locomotive: 303 kilometers

D. Operational Outlook

The 3,000-metric-ton train test reveals that the regulation 2,000-metric-ton load per train is low for summer operations; and the facts are that loading is constantly under the 2,000-ton figure, with consequent wastage of locomotive capacity, fuel, personnel, etc. It is hoped that more study will be given to the problem of eliminating underloading.

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